Bi H-T, Ph.D., "Flow Patterns of Gas-Solid Fluidization and Transport", The University of British Columbia, November 1994 (co-supervised, JR Grace of UBC as chief advisor).

Abstract

Experiments were carried out in three columns to study flow patterns of gas-solids fluidized beds. It was found that due to the existence of fluidized bed oscillations and the propagation of pressure waves, absolute pressure fluctuation measurements pick up signals from bubble motion, bed oscillation and pressure waves. Differential pressure fluctuation measurements using small spacing between the ports, however, register signals mostly from the passage of bubbles because the information from bed oscillation and pressure waves are filtered out to a great extent.

The transition velocity, U_c, was determined by measuring absolute pressure fluctuations, differential pressure fluctuations and local voidage fluctuations in a column of 0.102 m in diameter and 2 m tall using FCC particles. It was found that U_c varied with the method of measurement and with the signal interpretation. A mechanism of transition from bubbling to turbulent fluidization is proposed in which the transition is considered to be triggered when bubbles grow to such a size that their wakes become open and turbulent. Such a mechanism is in agreement with the experimental results from this study and with literature data

The corresponding transition in deep slugging systems has been studied using 0.22 mm diameter sand particles. Uc from differential pressure fluctuation and local voidage fluctuation measurements was found to correspond to the condition when the slug spacing becomes approximately the same as the slug length. It does not correspond to the transition to turbulent flow because slug flow persists beyond Uc. In shallow fluidized beds, Uc was found to be reached when the amplitude of the absolute pressure fluctuations can no longer increase with increasing superficial gas velocity because there is no more space to allow gas bubbles/slugs to grow. Uc in this case increases with increasing static bed height.

Gas-solids transport operation is reached when particles are significantly entrained from the column with increasing superficial gas velocity. A transition velocity Use corresponding to significant solids entrainment is proposed to define the transition from low velocity fluidization to high velocity fluidization operations.

Three types of choking are identified. Type A (accumulative) choking occurs as gas velocity is reduced for all systems when local refluxing (downward motion) of particles begins to such an extent that a dense region is formed at the bottom. Type B (blower-standpipe induced) choking takes place when either the blower is incapable of providing sufficient pressure head to maintain all the particles in suspension or when the standpipe which returns solids to the base of the riser is incapable of supplying the required flow of particles. Type C (classical) choking occurs only for systems capable of slugging, i.e. where bubbles can grow to a size comparable with the riser internal diameter.

Transition from fast/turbulent fluidization to dilute-phase transport is defined in this study by the Type A choking velocity below which fully-suspended transport collapses to form a dense bed at

the bottom of the column. The lowest boundary of the fast fluidization, on the other hand, is defined by the Types B and C choking velocities below which steady operation becomes unstable due to severe slugging of inappropriate pressure build-up in the whole unit.

Unified flow regime maps are proposed in which the transition velocities proposed in this study are incorporated to show the flow regimes ranging from packed bed to dilute-phase transport.